of matter is a necessary disciplinary corrective of all abstract thinking, whether scientific or not, and we should beware how we repress it lest we destroy that practical-mindedness which we treasure as one of the most valuable of our national assets. Imbued as we are with these convictions, it is discouraging to meet with opinions which appear to have been formed at a period when they were in some measure justified by the direct transference to the school of the practice of the university without the necessary adaptation to a lower intellectual plane, and by other inevitable errors of the early and empirical stage of science teaching. It is some relief, however, that the charge which has to be met is a matter of pounds, shillings and pence, and not one of squandering educational opportunity or of wasting human effort.

Economy bears upon science teaching precisely at it bears upon every branch of education and every department of social administration, nor do its principles perforce wither away in the atmosphere of science. As practical experience extends, as the supply of trained teachers improves, as examinations become more scientific and less restricted in style, so will the spirit of investigation and research be stimulated, and sound standards of thought be established. Indeed, the question of outlay will almost cease to be relevant as the relation of output to expenditure improves, but if definite statements be called for, a wide range of inquiry has furnished them. From the information thus gained, it appears that the present average expenditure on apparatus and material is about 1*l.* per annum for each pupil receiving practical instruction in science in the public schools, and about 10*s.* per annum for each pupil in other secondary schools. It may be safely accepted as a maximum estimate—a fairly generous one—that physical and chemical laboratories can be equipped, maintained in apparatus, and supplied with consumable material, and provision also be made for the practical study of animate nature, on a basis of 100 boys working for 10 hours a week (or 40,000 boy-hours per annum), by an average annual expenditure of 150*l.* for a period of ten years. After this period of installation and accumulation of plant, the annual cost of maintenance and renewal need not exceed 100*l.* In other words, the cost per head should never exceed 30*s.* a year during the early constructive stage, and may be expected to fall much below that value after a period varying with the scope of the work, the degree of specialisation, and the number of students. But it is imperative that expenditure should be guided by experience, for a wrong start by a tyro may hamper himself or his successor for years. For this reason there is much valuable work to be done by any independent body which would undertake to serve as a standing committee for the sifting and coordination of results in these matters, and for advising and guiding those in need.

Save for a few of the chief public schools, the statements here made in connection with secondary education are fortunately to a great extent unnecessary. There are now about 750 secondary schools in England and Wales inspected by the Board of Education and receiving grants for efficient teaching. In these schools there are about 100,000 pupils taking a course which has been approved by the Board, and this course must provide instruction in science. The Board insists that "the instruction in science must include practical work by the pupils." In each of these secondary schools, and they include most of the grammar schools and endowed schools of the country, one or more laboratories must be provided. They are to be fitted with benches for their special purpose, and supplied with water, gas, and, when possible, electric current. Sufficient apparatus must also be provided for a reasonable course of work.

The governing bodies of all these schools must provide laboratories and apparatus for individual practical work whether they like it or no. The schools are not regarded as efficient or entitled to receive grants in aid of education, unless they comply with the regulations laid down by the Board for individual practical work in science. Provision for this purpose cannot be evaded by any secondary school which receives grants in aid, nor, on the other hand, would any reduction in its cost permit the teaching to be extended beyond the limits already imposed by the rightful claims of other subjects. Secondary schools which are less local in character and not qualified to receive grants, but are subject to considerable competition among themselves, are prompted by motives of self-preservation to give a prominent position in their curricula to scientific training. It is now only a few public schools which remain in an exceptional position and offer but limited opportunities of learning science to a portion of their pupils. If an extension of science teaching in such schools be desired, the cost of its provision does not appear to be the real obstacle.

THE WORLD OF LIFE: AS VISUALISED AND INTERPRETED BY DARWINISM.[1]

THE lecturer began by stating that, although the theory of Darwinism is one of the most simple of comprehension in the whole range of science, there is none that is so widely and persistently misunderstood. This is the more remarkable, on account of its being founded upon common and universally admitted facts of nature, more or less familiar to all who take any interest in living things; and this misunderstanding is not confined to the ignorant or unscientific, but prevails among the educated classes, and is even found among eminent students and professors of various departments of biology.

Darwinism is almost entirely based upon those external facts of nature, the close observation and description of which constituted the old-fashioned "naturalists," and it is the specialisation in modern science that has led to the misunderstanding referred to. Those who have devoted years to the almost exclusive study of anatomy, physiology, or embryology, and that equally large class who make the lower forms of life (mostly aquatic) the subject of microscopical investigation, are naturally disposed to think that a theory which can dispense with all their work (though often strikingly supported by it) cannot be so important and far-reaching as it is found to be.

Numbers, Variety, and Intermingling of Life-forms.

Coming to the first great group of facts upon which Darwinism rests, the lecturer directed attention to the great number of distinct species, both of vegetable and animal life, found even in our own very limited and rather impoverished islands, as compared with more extensive areas. Great Britain possessed somewhat less than 2000 species of flowering plants, while many equal areas on the Continent of Europe have twice the number. The whole of Europe contains 9000 species, and the world 136,000 species already described; but the total number, if the whole earth were so well known as Europe, would be almost certainly more than double that number, or about a quarter of a million species. The following table, showing how much more crowded are the species in small than in large areas, was exhibited on the wall. It affords an excellent illustration of the fact of the great intermingling of species, so that large numbers are able to live in close contact with other, usually very distinct, species.

Numbers of Flowering Plants.[2]

	Square miles	Species
The County of Surrey	760	840
A portion containing	60	660
,, ,, ...	10	600
,, ,, ...	1	400

The above figures were given by the late Mr. H. C. Watson, one of our most eminent British botanists, and as he lived most of his life in the county, they are probably the results of his personal observation, and are therefore quite trustworthy.

Continuing the above inquiry to still smaller areas, one perch, equalling 1/160 acre, or less than the 1/100,000 of a square mile, has been found to have about forty distinct species, while on a patch 4 feet by 3 feet in Kent (or about 1/25,000,000 of a square mile) Mr. Darwin found twenty species.

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[1] Abstract of discourse delivered at the Royal Institution on Friday January 22, by Dr. Alfred Russel Wallace, O.M., F.R.S.

[2] Other tables illustrating similar facts in other parts of the world were prepared, but not exhibited, as being likely to distract attention from the lecture itself.

The same law of increase of numbers in proportion to areas applies to the animal world, if we count all the species that visit a garden or field during the year, though those that can continuously live there are not perhaps so numerous in very small areas.

The Increase of Plants and Animals.

The powers of increase of plants and animals were next discussed, and were shown to be enormously great. An oak tree may produce some millions of acorns in a good year, but only one of these becomes a tree in several hundred years to replace the parent. Kerner states that a common weed, *Sisymbrium Sophia*, produces about three-quarters of a million of seeds; and if all these grew and multiplied for three years, the plants produced would cover the whole land surface of the globe.

Equally striking is the possible increase in the animal world. Darwin calculated that the slowest breeding of all animals, the elephant, would in 750 years, from a single pair, produce nineteen millions. Rabbits, which have several litters a year, would produce a million from a single pair in four or five years, as they have probably done in Australia, where they have become a national calamity. As illustrative of this part of the subject, the lecturer referred at some length to the cases of the bison and the passenger pigeon in North America, and the lemmings of Scandinavia. In the insect tribes still more rapid powers of increase exist. The common flesh-fly goes through its complete transformations from egg to perfect insect in two weeks, and Linnæus estimated that three of these flies could eat up a dead horse as quickly as a lion.

It is these enormous powers of rapid increase that have ensured the continuance of the various types of existing life from the earliest geological ages in unbroken succession, while it has also been an important factor in the production of new forms which have successively occupied every vacant station with specially adapted species.

Inheritance and Variation.

The vitally important facts of inheritance with variation were next discussed, and their exact nature and universal application pointed out. The laws of the *frequency* and the *amount* of variations, and their occurrence in all the various parts and external organs of the higher animals, were illustrated by a series of diagrams. These showed the actual facts of variation in adult animals of the same sex obtained at the same time and place, which had been carefully measured in numbers varying from twenty to several thousand individuals.

The general result deduced from hundreds of such measurements and comparisons was that the individuals of all species varied around a mean value, that the numbers became less and less as we receded from that mean, and that the limit of variation in each direction was soon reached. Thus, when the heights of 2600 men, taken at random, were measured, those about 5 feet 8 inches in height were found to be far the most numerous. About half the total number had heights between 5 feet 6 inches and 5 feet 10 inches, while only ten reached 6 feet 6 inches, or were so little as 4 feet 10 inches, and at 6 feet 8 inches and 4 feet 8 inches there were only one of each.

The diagrams from the measurements of various species of birds and mammals were shown to agree exactly in general character, and the further fact was exhibited by all of them that the parts and organs varied more or less independently, so that the wings, tails, toes, or bills of birds were often very long, while the body or some other part was very short, a point of extreme importance, as supplying ample materials for adaptation through natural selection.

The Law of Natural Selection.

The next subject discussed was the nature and mode of action of natural selection. It was pointed out that since the Glacial epoch no decided change of species had occurred. This showed us that the adaptation of every existing species to its environment was not only special, but general. The seasons changed from year to year, but the extremes of change only occurred at long intervals, perhaps of many centuries, with lesser, but still very considerable, variations twice or thrice in a century. It was by the action of these seasons of extreme severity at long intervals, whether of arctic winters or summer droughts, that the very existence of species was endangered; and it was at such times that the enormous population of most species and their wide range over whole continents always secured the preservation of considerable numbers of the best adapted in the most favoured localities. Then the rapidity of multiplication came into play, so that in two or three years the population of each species became as great as ever, while, as all the least favourable variations had been destroyed, the species as a whole had become better adapted to its environment than before the almost catastrophic destruction of such a large proportion of them.

It is the fact of the adaptation of almost all existing species to a continually fluctuating environment—fluctuating between periodical extremes of great severity—that has produced an amount of adaptation that in ordinary seasons is superfluously complete. This is shown by the well-known fact that large numbers of adult animals that have not only reached maturity, but have also produced offspring and successfully reared them, continue to live and breed for many years in succession, although varying considerably from the mean, while almost the whole of the inexperienced young fall victims to the various causes of destruction that surround them.

The Nature of Adaptation.

The next subject discussed was the complex nature of adaptations in many cases, and probably in all, a subject of great extent and difficulty. The lecturer directed special attention to the relations between the superabundance of vegetation in spring and summer, the enormous, but to us mostly invisible, hosts of the insect tribes which devour this vegetation, and the great multitudes of our smaller birds the young of which are fed almost exclusively on these insects. Without these hosts of insects the birds would soon become extinct, while without the birds the insects would increase so enormously as to destroy a considerable amount of vegetable life, which would, in its turn, lead to the destruction of much of the insect, and even of the highest animal groups, leaving the world greatly impoverished in its forms of life.

The vast numbers of insects required daily and hourly to feed each brood of young birds was next referred to, and the wonderful adaptation of each kind of parent bird which enables it to discover and to capture a sufficient quantity immediately around its nest, in competition with many others engaged in the same task in every copse and garden, was next pointed out. The facts were shown to involve specialities of structure, agility of motions, and acuteness of the senses, which could only have been attained by the preservation of each successive slight variation of a beneficial character throughout geological time; while the emotions of parental love must also have been continuously increased, this being the great motive power of the strenuous activity exhibited by these charming little creatures.

Lord Salisbury on Natural Selection.

As illustrating the strange and almost incredible misconceptions prevailing as to the mode of action of natural selection, the lecturer quoted the following passage from the late Lord Salisbury's presidential address to the British Association at Oxford in 1894. After describing how the diverse races of domestic animals have been produced by artificial selection, Lord Salisbury continued thus:—

"But in natural selection, who is to supply the breeder's place? Unless the crossing is properly arranged the new breed will never come into being. What is to secure that the two individuals of opposite sexes in the primæval forest, who have been both accidentally blessed with the same advantageous variation, shall meet, and transmit by inheritance that variation to their successors? Unless this step is made good the modification will never get a start; and yet there is nothing to ensure that step but pure chance. The law of chance takes the place of the cattle-breeder or the pigeon-fancier. The biologists do well to ask for an immeasurable expanse of time, if the occasional meetings of advantageously varied couples, from age to age, are to provide the pedigree of modifications which unite us to our ancestors, the jelly-fish."

Here we have the extraordinary misconception presented to a scientific audience as actual fact, that advantageous variations occur singly, at long intervals, and remote from each other, each statement being, as is well known, the absolute reverse of what is really the case. It totally ignores the fact that every abundant species consists of tens or hundreds of millions of individuals, and that as regards any faculty or quality whatever, this vast host may be divided into two portions—the *less* and the *more* adapted—not very unequal in amount. It follows that at any given time, in any given country, the advantageous variations always present are not to be counted by ones and twos, as stated by Lord Salisbury, but by scores of millions; and not in individuals widely apart from each other, but constituting in every locality or country somewhere about one-half of the whole population of the species.

The facts of nature being what they are, it is impossible to imagine any slow change of environment to which the more populous species would not become automatically adjusted under the laws of multiplication, variation, and survival of the fittest. Almost every objection that has been made to Darwinism assumes conditions of nature very unlike those which actually exist, and which must, under the same general laws of life, always have existed.

Protective Colour and Mimicry.

The phenomena of protective coloration and mimicry were very briefly alluded to both because they are comparatively well known and had formed the subject of previous lectures, while they are very easily explained on the general principles now set forth. The explanation is the more easy and complete, because of all the characters of living organisms, colour is that which varies most, is most distinctive of the different species, and is almost universally utilised for concealment, for warning, or for recognition; and, further, its useful results are clear and unmistakable, and have never been attempted to be accounted for in detail by any other theory than that of the continuous selection of beneficial variations.

The Dispersal of Seeds.

The subject of the dispersal of seeds through the agency of the wind, or of carriage by birds or mammals in a variety of ways, and often by most curious and varied arrangements of hooks, spines, or sticky exudations almost infinitely varied in the different species, was also briefly treated, since they are all readily explicable by the laws of variation and selection, while no other rational explanation of their formation has ever been given.

Conclusion.

In concluding, the lecturer directed attention to a series of cases which had shown us the actual working of natural selection at the present time. He also explained that these cases were at present few in number, first, because they had not been searched for, but perhaps mainly because they only occur on a large scale at rather long intervals, when some great and rather rapid modification of the environment is taking place.

In the following paragraph he endeavoured to summarise the entire problem and its solution:—"It is only by continually keeping in our minds all the facts of nature which I have endeavoured, however imperfectly, to set before you, that we can possibly realise and comprehend the great problems presented by the 'World of Life'—its persistence in ever-changing but unchecked development throughout the geological ages, the exact adaptations of every species to it actual environment both inorganic and organic, and the exquisite forms of beauty and harmony in flower and fruit, in mammal and bird, in mollusc and in the infinitude of the insect-tribes; all of which have been brought into existence through the unknown but supremely marvellous powers of Life, in strict relation to that great law of Usefulness, which constitutes the fundamental principle of Darwinism."

LONG-DISTANCE TELEGRAPHY.

THE developments which have recently taken place in long-distance direct telegraphic working show that progress has been made in telegraphic transmission by wire as well as in wireless telegraphy. The direct transmission of public messages between London and India was put into operation last week, and messages were sent at the rate of forty words per minute between London and Karachi. Direct working with Calcutta, Bombay, and Madras has been successfully established, the experiment of direct transmission to the first-named centre being attempted for the first time last Saturday, when a world's record was established of about 7000 miles.

Direct Wheatstone working over the line between London and Teheran—a distance of 3748 miles—has been possible since the beginning of 1903, but no land line existed between Teheran and Karachi. This line has been recently erected by the Indo-European Department of the India Office, and was put into operation in November, 1907, bringing the total length of line—London to Karachi—up to 5532 miles. Wheatstone automatic transmission is used throughout the line, and many improvements in telegraphic instruments which have been introduced in recent years have been installed. One of the latest key-board perforators is the Kotyra, which is so arranged that the key-board is made to actuate three electromagnets so constructed that the necessary number of blows are communicated to the keys of a Wheatstone perforator. At each relay station a receiving apparatus is placed in circuit enabling the operator in charge to see how the signals are leaving that station, and any fault in regulation can be at once rectified.

The great advantage of being able to transmit direct messages over such distances is that, apart from the time saved and the consequent increase in the capacity of the line, greater accuracy is ensured owing to the fact that no intermediate handling takes place. Thus liability to error is reduced to a minimum. The importance of this will be understood when it is realised that 1600 messages per diem—97 per cent. of which are in code—are sent on the average over this line. The Indo-European Telegraph Company and the Telegraphic Department of the India Office have, with the cooperation of the Indian Government, achieved a great success, considering the enormous difficulties attendant upon a land line traversing every variety of country and exposed to all sorts of climatic conditions. J. L. M.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. H. F. Newall, F.R.S., has been elected a fellow of Trinity College. Mr. Newall has been engaged for many years in astrophysical research at the observatory, in connection with a large Equatorial presented to the University by his father. He was formerly an assistant to the Cavendish professor of physics, and demonstrator in the Cavendish Laboratory. He is at present assistant director of the Observatory, treasurer of the Cambridge Philosophical Society, and president of the Royal Astronomical Society. Mr. Newall, by his continuous generosity, has firmly established the study of astrophysics in the University, and to him the University owes a considerable debt of gratitude.

LONDON.—A course of eight lectures on national eugenics, in connection with the Galton Laboratory, will be given at University College on Tuesdays at 5 o'clock, beginning on February 23. The first lecture will be given by Prof. Karl Pearson, on "The Purport of the Science of Eugenics." On the four following Tuesdays the lectures will be given by Mr. D. Heron, and will deal with the following subjects:—methods of eugenic inquiry; transmission of physical characters in man; transmission of psychical characters in man; inheritance of disease and deformity. The course will be continued in the third term, beginning on May 4, when Miss E. Elderton will lecture on "Effects of Kinship in Marriage" and "Comparison of Heredity and Environmental Factors." Full par-